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(54) **SYSTEM AND PROCESS FOR PROCESSING FRESH PRODUCE**

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A23B 7/158	(2006.01)
A23L 1/00	(2006.01)
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A23N 12/06	(2006.01)
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(58) **Field of Classification Search**

CPC A23B 7/157; A23B 7/158; A23N 15/00; A23N 12/02; A23N 12/06; A23L 1/0011

See application file for complete search history.

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(57) **ABSTRACT**

Thorough spraying and draining freshly cut produce and the equipment processing it in a one-pass system that uses a dilute solution of chilled ultrapure water and chlorine dioxide or chlorine or both significantly reduces bacterial counts. Raw produce is sprayed as it is conveyed to cutting heads and as the cut pieces fall into a hopper above a conveyor. The conveyed cut produce is vibrated and tumbled while being sprayed from above. At the end of the process, the cut produce is sprayed with potable water and deposited in a dryer basket. Drainage from the equipment is collected and processed through a multi-stage water filtration system to potable quality. The near freezing water temperature, its ultra-purity, and the concentrations of biocides in the sanitizing spray are carefully established, monitored and maintained by a process controller.

18 Claims, 2 Drawing Sheets

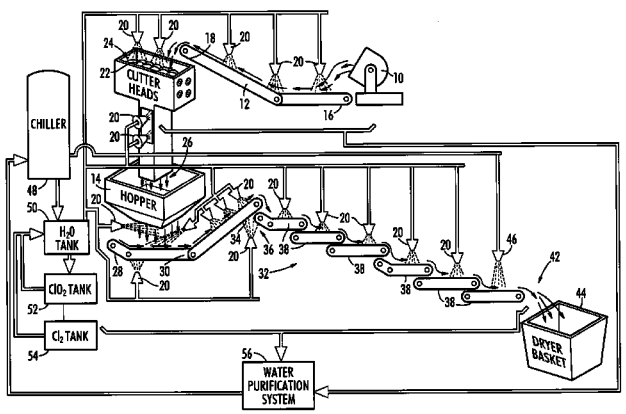

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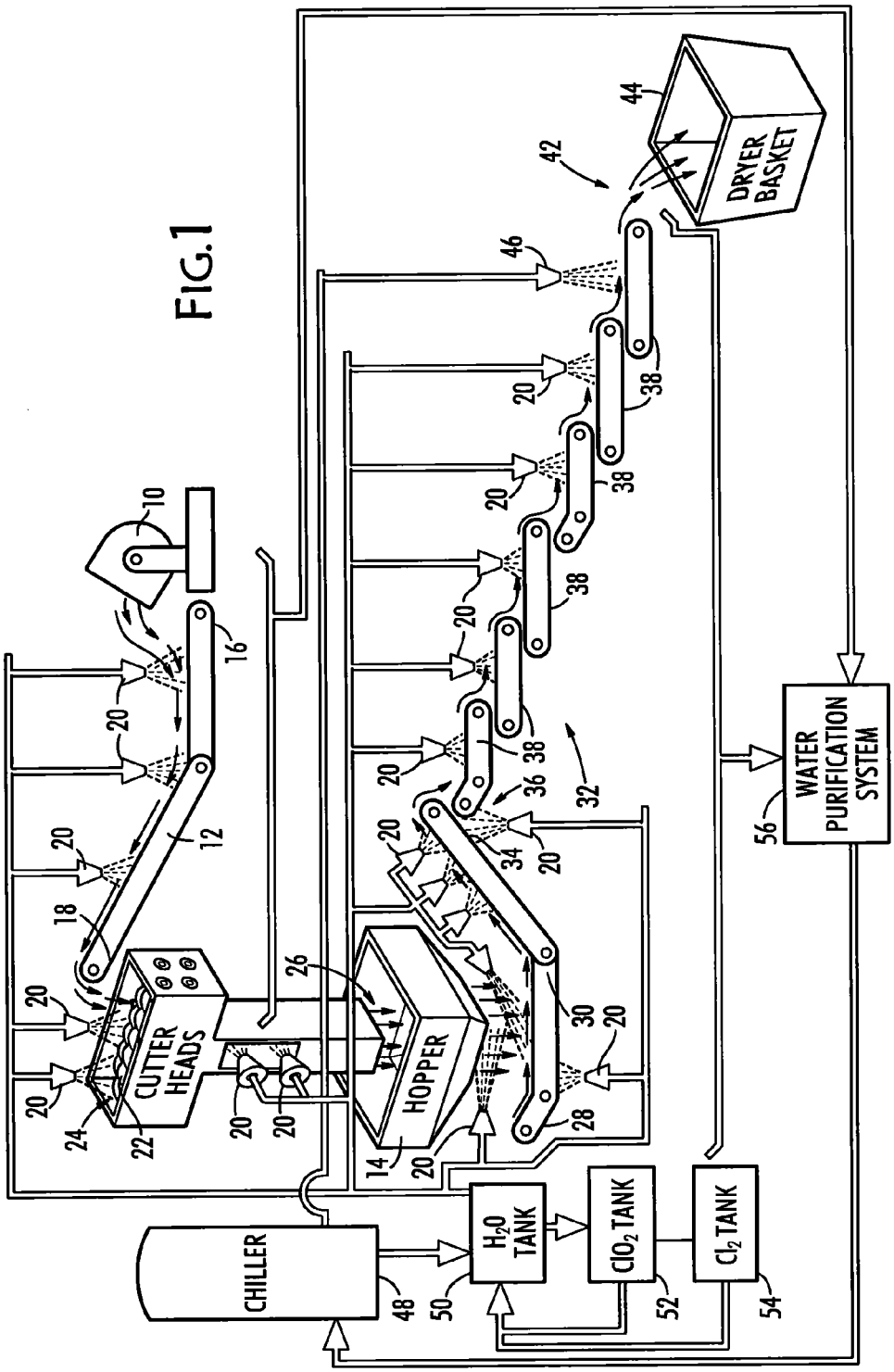
FIG.1


DRYER BASKET
WATER PURIFICATION SYSTEM
CUTTER HEADS
HOPPER
CHILLER
H_2O TANK
ClO_2 TANK
Cl_2 TANK
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
42
44
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48
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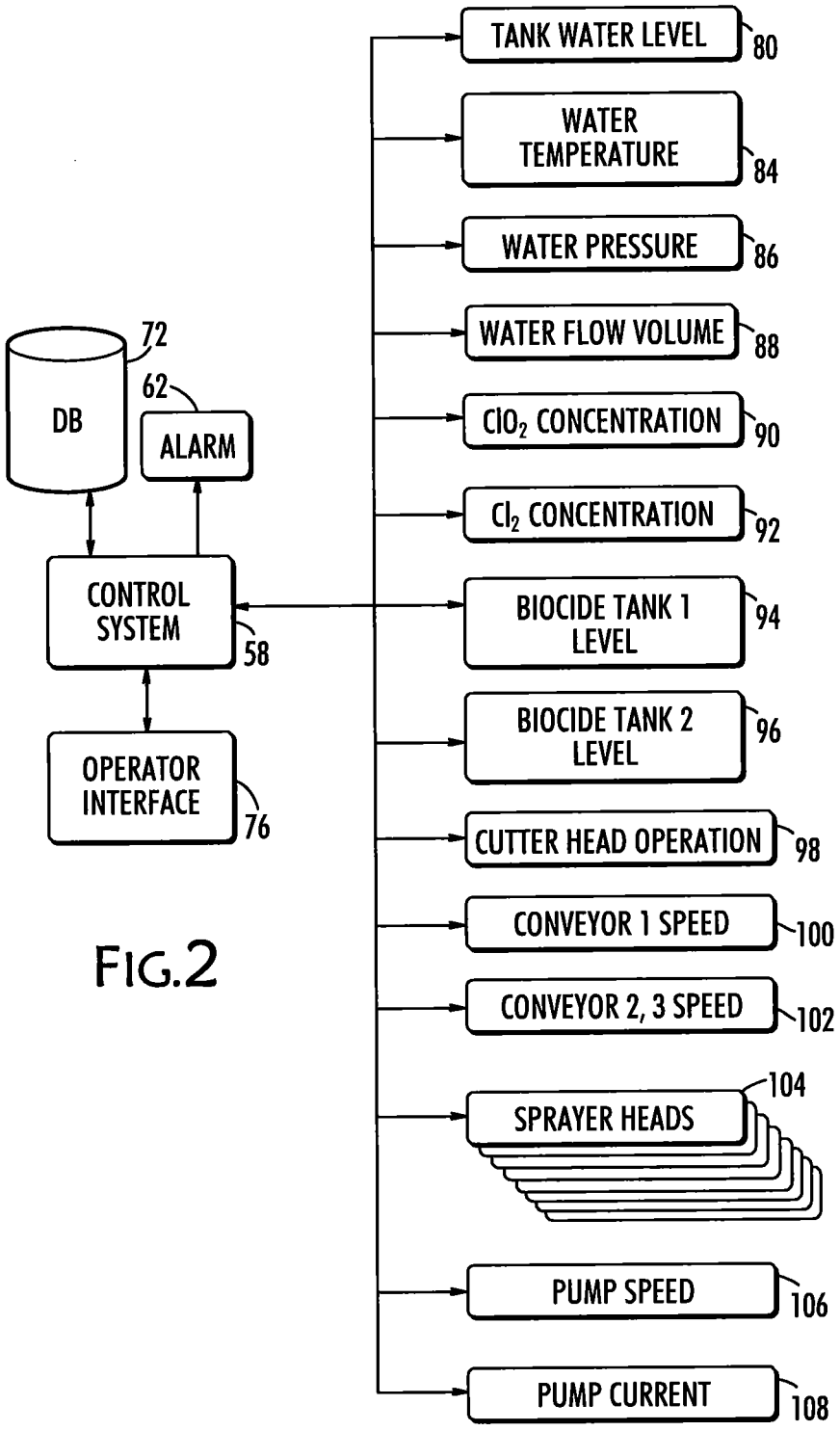
TANK WATER LEVEL
80
WATER TEMPERATURE
84
WATER PRESSURE
86
WATER FLOW VOLUME
88
ClO_2 CONCENTRATION
90
Cl_2 CONCENTRATION
92
BIOCIDE TANK 1 LEVEL
94
BIOCIDE TANK 2 LEVEL
96
CUTTER HEAD OPERATION
98
CONVEYOR 1 SPEED
100
CONVEYOR 2, 3 SPEED
102
SPRAYER HEADS
104
PUMP SPEED
106
PUMP CURRENT
108
DB
72
62
ALARM
CONTROL SYSTEM
58
OPERATOR INTERFACE
76

FIG.2

SYSTEM AND PROCESS FOR PROCESSING FRESH PRODUCE

PRIORITY CLAIM

Priority is claimed to U.S. provisional patent application Ser. No. 61/870,524 filed Aug. 27, 2013, and which is incorporated herein it its entirety by reference.

SUMMARY OF THE INVENTION

The present invention is a system for processing fresh produce, and in particular, processing it by cutting it into pieces prior to packaging for eventual purchase by consumers. The present processing reduces bacteria on the raw produce by several orders of magnitude using a biocide wash on both the produce and the processing equipment. Conveyors convey the produce, first to cutting heads in an industrial cutter, and then from the cutter to a series of washing screens. While being conveyed to the industrial cutting heads, the produce is washed by spray heads to rid it of organic material and to make it more sanitary. The sanitizing solution is directed from sprayer heads not only on the produce before and after cutting, but also at the conveyors, the hopper, and the cutting heads. The sanitizing spray is not reused; it is used only once, then collected and filtered to a purified water state. The temperature, water purity, and concentration of the particular biocide used, namely, chlorine dioxide, chlorine (sodium hypochlorite) or a combination of both, in the sanitizing spray are carefully established, monitored and maintained. When using chlorine (sodium hypochlorite), an acid buffer must also be used to control PH when higher strengths of chlorine are necessary.

The uncut produce is dumped from a bin onto a first conveyor that conveys it to the in-feed of a cutter where it is fed into and through a set of cutting heads that cut it into pieces. The cut produce then falls from the cutter into a hopper at the start of an incline wash conveyor. The cutting heads of the industrial cutter are exposed to the sanitizing spray to clean both the produce and the cutting heads inside the blade housing. In addition, the pieces of cut produce are also sprayed as they fall from the cutter into the hopper below. The surface of the incline wash conveyor is also sprayed and is perforated to allow the received spray to drain quickly. Sprayer heads direct the spray at the top surface of the first conveyor and at the top and bottom of the incline wash conveyor. These sprays remove exudate, foreign material and fine cuttings from the product.

The produce proceeds to a decline conveyor having one conveyance with six tiers; each successive tier is positioned slightly below the previous tier so that the produce tumbles as it moves from one tier to the next, thereby presenting its different sides to the sanitizing spray and draining more efficiently.

The water for the sanitizing spray conies from a tank storing ultrapure water, the output from a water purification system that uses an ultrafiltration system to remove organisms and contaminants. A multistage filtration system filters particles and macromolecules from water to produce potable water, and is capable of removing 90%-100% of total plate count and coliform. The water tank is connected to a chiller tank that is connected to a first and second biocide tank containing chlorine dioxide (ClO_2) and Chlorine (Cl_2), respectively. A controller directs a small amount of ClO_2 or Cl_2, or both, from these tanks into the chiller tank where it is mixed with ultrapure water from the water tank and chilled. The two mix to form a sanitizing solution with a concentration of 0.01 to 2.99 parts per million (ppm) ClO_2 and/or 0.01 to 200 parts per million (ppm) Cl_2. From the chiller, the controller causes the mixture to be pumped through a manifold to individual sprayer heads for use on the produce and equipment processing it.

Other features and their advantages will be apparent to those skilled in the art of processing fresh produce from a careful reading of the Detailed Description of Embodiments accompanied by the following Drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is diagram of the system and method for processing produce; and

FIG. **2** is a schematic diagram of the controls for the present system and method for processing produce.

DETAILED DESCRIPTION OF EMBODIMENTS

The present produce washing system and process is comprehensive and thorough, and provides significant improvements over open and closed flume wash systems in removing organic load, exudate, insects and foreign material and reducing the initial bacterial count on the raw produce by several orders of magnitude. The present process and system capabilities allow for thorough cleaning of fresh produce in a controlled interior environment thereby reducing a broader spectrum of bacteria by an order of magnitude equal to or greater than conventional fresh produce wash flume systems all the while using a relatively lower volume of water and less total chlorine and chlorine dioxide. This outcome results from the thoroughness of the spraying of both the produce and the equipment with a chilled sanitizing solution and use of a potable water spray finish. And, as important as the thorough spraying with chlorinated and chlorine dioxide water is, the inherent avoidance of re-exposure of the produce to an accumulation of a broader spectrum of bacteria from reused water and the buildup over time of a broader spectrum of bacteria on unclean equipment that is in the conventional wash flume system is even more significant. It is insufficient to remove the bacteria from one batch of produce only to allow that produce to come into contact with same bacteria as was removed from the previous batches via reused water and unclean equipment. The present wash system removes wash water and equipment in contact with the wash water as a source of cross contamination.

Referring now to FIG. **1**, the present process begins by transferring the produce from a bin **10** onto a first conveyor **12** that moves it to cutting heads **22**. The produce is put into bin **10** which may be rotated to transfer the produce onto a first end **16** of first conveyor **12**. First conveyor **12** transfers the produce to a second, opposing end **18** of first conveyor **12** proximate to cutting heads **22** of an industrial cutter. As the produce is being transferred, it is sprayed by sprayer heads **20** with a sanitizing solution to remove organic material, including foreign material and insects. The speed of first conveyor **12** and the flow rate of sanitizing solution spray are selected for the particular type of produce and its source in order to provide sufficient time to wash both the produce and the surface of first conveyor **12** on which it travels. Cutting heads **22** have an inlet **24** and an opposing outlet **26**. Between inlet **24** and outlet **26**, cutting heads **22** cut the produce into suitably-sized pieces ranging from coarsely chopped lettuce to diced onions. The pieces of produce fall from outlet **26** and into a hopper **14** above a first end **28** of a second conveyor **30**, which may be an incline conveyor, to its second end **34**. Meanwhile sanitizing solution is sprayed onto the produce as

it falls into hopper **14** from cutting heads **22**. Both organic materials washed from the produce and the sanitizing solution itself are immediately drained through the perforated surface of second conveyor **30**. The term perforated means the support surface of the conveyor has a multiplicity of holes, such a screen, grid, or metal sheet with an array of holes.

Second conveyor **30** transfers produce from its first end **28** to an opposing second end **34** where produce is transferred to a first end **36** of a third conveyor **32** which may be a decline conveyor. Third conveyor **32** moves product down a set of tiers **38** while spraying heads **20** direct sanitizing solution at the produce pieces from above and the perforated surface of third conveyor **32**. Each tier **38** of third conveyor **32** is slightly lower than the level of the preceding tier **38** so that the produce tumbles from tier to tier to thereby expose different sides of the produce pieces to the spray from sprayer heads **20**. Each tier **38** may also vibrate to encourage drainage and the spread of the produce pieces laterally for improved cleaning and sanitizing. Tumbling and vibrating the produce pieces assures that all sides of each of the pieces of produce are presented to the sprayer heads **20** for thorough washing. At second end **42** of third conveyor **32**, the produce is transferred to a dryer basket **44** where continued draining of moisture occurs. As the cut produce travels over tiers **38** of third conveyor **32**, it is sprayed from above by sprayer heads **20** for thorough washing. At second end **42** of third conveyor **32**, the cut produce is sprayed with potable water from a sprayer **46**, rather than sanitizing solution, before it falls into dryer basket **44**. Total dwell time on second and third conveyors **30**, **32**, may be a minimum of fifty seconds but is adjustable as needed.

The supply of sanitizing solution comes from a Chiller **48** for chilling to less than 5 degrees C. (40 degrees F.), as needed. It is directed from there to a water tank **50** for storage. Water tank **50** receives biocide from either a first biocide tank **52** containing ClO_2 and from a second biocide tank **54** containing Cl_2, or from both, to mix with the chilled water to produce the concentrations needed for effective reduction of pathogens. As the level of water tank **50** falls, it is refilled from water purification system **56**, which is the collected drainage from conveyors **12**, **30**, **32**, from cutting heads **22**, and from dryer basket **44** that has been subsequently processed. This water is purified by a multi-stage filtration system to purified level before pumping to water chiller **48** and subsequently, to water tank **50**. Water purification removes macromolecules, pathogens and particulate to between 90%-100%. Well water or municipal city water may also be used in combination with purified water to supply water chiller **48** and subsequently, water tank **50** for the simply clean process.

Chlorine dioxide is a preferred biocide, but, by adding a free chlorine probe, the system is then capable of using Chlorine (Cl_2), otherwise known as sodium hypochlorite, in the place of or in addition to ClO_2 at strengths ranging from 1 ppm free chlorine to 200 ppm of free chlorine with the use of buffers or other chemicals to achieve higher ClO_2 strength.

Each tier **38** of third conveyor has a perforated surface with holes sized for removal of fines, insects, foreign material or "off size" (i.e., small) pieces by the pressurized water sprayer heads **20**. These surfaces may be removed for sterilization as well as to substitute perforation patterns and sizes (both the surfaces and sprayer heads are designed to simplify change out) as various types of produce may be cut in different ways and into different sizes.

Each tier **38** may have four spray bars consisting of six spray heads per bar for thorough dispersion of sanitizing solution. Typically two spray bars per tier may be in use with typical produce. The other two spray bars per tier can be activated when the organic load is heavier. Sprayer heads **20** may be confined under a removable stainless steel hood to limit the extent to which sanitizing solution is dispersed, an important consideration since the biocide is a chlorine-based compound. The water pressure may also be adjustable to allow the force and volume of sanitizing solution to be tuned to the particular produce type and source.

The sanitizing solution sprayer heads **20** that are directed at cutting heads **22** are high-volume, one-pass, pressurized wash sprays designed to wash off the heaviest load of organic material, or exudate, and thereby significantly reduce bacterial count. These pressurized sprayer heads **20** are fed from water tank **50**, described in more detail below. Sprays from sprayer heads **20** also help to reduce product bruising as they slow the produce as it leaves outlet **26** and enters hopper **14**.

The present system and process is controlled by a control system **58**, which is operated via an operator interface **76**, as best seen in FIG. **2**. Control system **58** is connected to valves and sensors to manage the operation in accordance with programmed protocols, limits, and settings. Control system monitors and controls the water tank level **80**, water temperature **84**, water pressure **86**, water flow volume **88**, ClO_2 concentration **90** in the sanitizing solution, free Cl_2 concentration **92** in the sanitizer solution, a first biocide tank level **94** (for ClO_2), a second biocide tank level **96** (for free Cl_2), cutter head operation **98**, first conveyor speed **100**, second and third conveyor speed **102**, sprayer head operation **104**, pump speed **106**, and pump electrical current **108**. This information is displayed by operator interface **76** and stored in a database **72**.

The speeds of conveyors **12**, **30**, **32**, are adjustable by control system **58** to accommodate the particular type of produce being processed. Speed control is critical to ensure the flow of raw product does not exceed the sanitizing and washing capability of the system but still provide good through-put. Similarly, because the concentration of ClO_2 and Cl_2 are critical to pathogen reduction, the sanitizing solution concentrations of these biocides are periodically measured using meters before and after it has come into contact with the produce to verify the concentration has not fallen below a minimum of 1.0 ppm ClO_2 and but remains near the nominal 1.25 ppm level. Cl_2 concentrations may range from 0.1 to 200 PPM but are held close to 15 PPM. Concentration measurements provided to control system **58** enable it to determine when the concentration of ClO_2 in the sanitizing solution needs to be increased.

This system uses water processed through a water purification system **56**, and may also use well water or municipal city water, and is chilled in chiller **48**, such as an ammonia plate chiller to reduce its temperature to between 1 and 5 degrees Celsius (33 and 40 degrees Fahrenheit), and stored in water tank **50**, The use of very pure, very cold water enables the present system and process to begin with a clean source of water rather than one carrying bacteria from previous uses, and also one that slows the growth of bacteria carried on the produce because of its low water temperature.

The water is mixed with a small amount of ClO_2 from 1st biocide tank **52** or of Cl_2 from biocide tank **54** or both and a buffer from water tank **50** to form a sanitizing solution. The ClO_2 and/or Cl_2 and buffer concentrations in the sanitizing solution are established, monitored, and controlled by control system **58**, which detects the concentration of ClO_2 and free Cl_2 and injects additional ClO_2 or free Cl_2 as needed to maintain average concentrations of 1.25 PPM of ClO_2 and of 15 PPM of free chlorine; additionally, PH is monitored and controlled to a target of 5.0 with a range of 4 to 6.5 in the sanitizing solution. If control system **58** senses a concentration outside of the pre-selected range, it issues an alarm **62**

and halts production. Production may not be restarted and the sanitizing solution may not resume flowing until the correct range is reached.

Each produce line is independent of other produce lines and has its own water chilling system with its own sanitizing solution concentration range specific for the particular raw commodity to be processed. This product separation also helps to reduce cross contamination.

ClO_2 has numerous advantages over chlorine. Unlike chlorine, which has a biocidic activity that declines as the pH of the solution increases or decreases, the biocidic activity of ClO_2 is consistent over a broad pH range. Furthermore, the effectiveness of chlorine as a biocide at low concentrations is more limited than that of ClO_2. In fact, ClO_2 can achieve a 5 log reduction in pathogens at low dosages in less than 60 seconds and has been shown to be more effective in limiting regrowth of bacteria than chlorine. Additionally, the concentration of chlorine is much harder to maintain in water with large concentrations of organic materials. And perhaps most importantly, chlorine reacts with organic materials with a chlorinating reaction that results in carcinogenic by-products, but ClO_2, on the other hand, operates based on an oxidizing reaction that inhibits production of carcinogenic by-products

At each step in the process, sprayer heads **20** are directed either at the produce or at the equipment or both. Water alone may remove organic matter, exudate, foreign materials and insects, but, in addition, the bacterial count must be reduced by several orders of magnitude. The use of ultrapure water avoids adding pathogens to those that are present on the produce. The sanitizing solution is used in a one-pass mode, which means that, once applied, the sanitizing solution is drained from the produce, collected and, processed to yield potable water, but is not reused before it is purified. Implicitly, not re-using sanitizing solution means that there are no pipes that lead directly back to the water storage tank **50** or water chiller **48** from the collected fluids in the present process. Also, because sanitizing solution is not reused, there is no organic load requiring treatment with buffers, anti-foam agents or other chemical additives. Additionally, the total volume of sanitizing solution used and total sanitizing solution required to be brought into contact with the produce in order to attain the solution strength are both greatly reduced.

Applying sanitizing solution to the equipment prevents accumulation of bacteria from each batch of produce. Care is taken to spray the produce thoroughly, such as spraying produce from above on conveyor **12**, spraying the pieces of produce falling from cutter heads **22** and spraying pieces of cut produce as it moves down conveyors **30**, **32**, and tumbling the produce as it passes from one tier **38** of conveyor **32**, to the next tier **38** so that all sides of the produce present themselves to the sprayer heads **20**. The presence of a modest concentration of ClO_2 and/or Cl_2 in the sanitizing solution effectively reduces the bacteria and other pathogens. Keeping the sanitizing solution cold helps to prevent re-growth of the bacteria. Separating product lines also helps to prevent cross contamination and allows for variations in the biocide concentration for the peculiarities of different types of produce. The result of these steps taken in the present process is a reliable, repeatable, multiple-order-of-magnitude reduction in bacterial count from fresh, raw produce to processed produce ready for consumption.

Control system **58** stores produce feed rates and sanitizing solution concentration ranges in a database **72** for each commodity and type of cut. These data inform general settings which may be modified when unusual conditions exist on the raw product to achieve consistent product quality. Icons and product codes simplify use of control system **58** when an operator is programming it for each type of produce. If the system fails to maintain the specified sanitizing solution concentration range, the control system will automatically shut down conveyors **12**, **30**, **32**, and cannot be restarted until the sanitizing solution concentration is restored to a value within the specified range. Furthermore, production personnel are precluded from controlling this system; management oversight is required for restart.

In the foregoing description of embodiments of the invention and accompanying drawings, particular aspects are deemed especially important for eliminating or at least significantly reducing cross contamination risks compared to prior art systems for processing fresh produce. These include spraying the produce, conveyors, cutter heads, and other equipment while the produce is being processed including the underside of the conveyors; using free chorine and chloride dioxide as a bactericide; spraying the produce as it falls from the cutting heads and while shaking and tumbling it after cutting; and use of pure, chilled water; and not recycling process water. Within these, various adjustments can be made to improve outcomes when different types of produce from different sources is being processed, namely, adjusting the throughput of produce, adjusting the number of sprayers and the sprayed volumes, adjusting the speed of the conveyors, lengthening or shortening the conveyors, changing the size of the perforations on the screens, and adjusting the concentration of bactericide in the water. A modest amount of experimentation will enable those skilled in the art of processing fresh produce to locally optimize the present process as described herein for their specific circumstances.

Those skilled in the art of processing fresh produce will appreciate that many substitutions and modification may be made to the embodiments described above without departing from the spirit and scope of the present invention, as defined by the appended claims.

What is claimed is:

1. A system for processing fresh produce for use with a source of water, said system comprising:

(a) a source of a sanitizing solution comprising a mixture of water and ClO_2, Cl_2 or combinations thereof;

(b) a first conveyor having a first end and an opposing second end, said conveyor adapted to move raw produce from said first end to said second end;

(c) a cutter having cutting heads, said cutter being proximate to said second end of said first conveyor, said cutter able to receive said produce from said second end of said first conveyor, said cutting heads cutting said produce into pieces;

(d) a hopper having an inlet and an opposing outlet, said inlet being below said cutter so that said pieces of said produce are received in said hopper;

(e) a second conveyor having a first end and a second end, said first end of said second conveyor being proximate to and below said outlet of said hopper to receive said pieces of said produce from said outlet of said hopper;

(f) a third conveyor having a sequence of tiers and a first and an opposing second end, said second end of said second conveyor depositing said produce onto said first end of said third conveyor, and wherein each subsequent tier of said third conveyor is at a lower elevation than a previous tier of said conveyor, so that said produce on said each previous tier tumbles when falling from said previous tier to said subsequent tier at said lower elevation;

(g); plural sprayer heads in fluid connection with said source of sanitizing solution and positioned proximate to said first and second conveyors, and proximate to said

cutting heads, said hopper, and between said cutting heads and said hopper, said sprayer heads adapted to spray said sanitizing solution on said produce, on said first and said second conveyors from above and below, on said hopper while said first and second conveyors are moving, and said cutting heads are cutting; and

(h) a control system in operative connection with said sprayer heads, said first and said second conveyors, said cutting heads, and said source of sanitizing solution, wherein said sprayer heads, said first and said second conveyors, and said cutting heads are responsive to signals from said control system.

2. The system as recited in claim **1**, wherein said first end of said second conveyor and said outlet of said hopper are spaced apart to define a space and wherein said sprayer heads spray said sanitizing solution into said space so that, as said produce falls from said cutter heads to said hopper and onto said second conveyor, said produce is exposed to said sanitizing solution.

3. The system as recited in claim **1**, wherein said tiers in said sequence of tiers of said third conveyor are vibrated to spread said produce and shake sanitizing solution from said produce.

4. The system as recited in claim **1**, wherein said first and said second conveyors have drain holes formed therein to drain said sanitizing solution.

5. The system as recited in claim **1**, wherein said mixture has a concentration of at least 1.0 PPM ClO_2 and less than 3.00 PPM.

6. The system as recited in claim **1**, wherein said concentration is controlled by said controller to a target of 1.25 PPM ClO_2.

7. The system as recited in claim **1**, wherein said water is ultrapure water.

8. The system as recited in claim **1**, further comprising a chiller and wherein said water is chilled to a temperature between 1 degree C. and 5 degrees C.

9. The system as recited in claim **1**, wherein said mixture is collected but not re-used.

10. The system as recited in claim **9**, further comprising a water purification system for processing said collected mixture.

11. The system as recited in claim **1**, wherein said sanitizing solution further comprises a buffer.

12. A system for processing fresh produce for use with a source of water, said system comprising:

(a) a source of a sanitizing solution;

(b) a first conveyor having a first end and an opposing second end, said conveyor adapted to move raw produce from said first end to said second end;

(c) a cutter having cutting heads, said cutter being proximate to said second end of said first conveyor, said cutter able to receive said produce from said second end of said first conveyor, said cutting heads cutting said produce into pieces;

(d) a hopper having an inlet and an opposing outlet, said inlet being below said cutter so that said pieces of said produce are received in said hopper;

(e) a second conveyor having a first end and a second end, said first end of said second conveyor being proximate to and below said outlet of said hopper to receive said pieces of said produce from said outlet of said hopper;

(f) a third conveyor having a sequence of tiers and a first and an opposing second end, said second end of said second conveyor depositing said produce onto said first end of said third conveyor, and wherein each subsequent tier of said third conveyor is at a lower elevation than a previous tier of said conveyor, so that said produce on said each previous tier tumbles when falling from said previous tier to said subsequent tier at said lower elevation;

(g) plural sprayer heads in fluid connection with said source of sanitizing solution and positioned proximate to said first, second conveyors, and third conveyors, and proximate to said cutting heads, said hopper, and between said cutting heads and said hopper, said sprayer heads adapted to spray said sanitizing solution on said produce, on said first, said second and said third conveyors from above and below, on said hopper while said first and second conveyors are moving, and said cutting heads are cutting; and

(h) a control system in operative connection with said sprayer heads, said first and said second conveyors, said cutting heads, and said source of sanitizing solution, wherein said sprayer heads, said first and said second conveyors, and said cutting heads are responsive to signals from said control system.

13. The system as recited in claim **12**, wherein said tiers in said sequence of tiers of said third conveyor are vibrated to spread said produce and shake sanitizing solution from said produce.

14. The system as recited in claim **12**, wherein said first, said second, and said third conveyors have drain holes formed therein to drain said sanitizing solution.

15. The system as recited in claim **13**, wherein said water is ultrapure water.

16. The system as recited in claim **13**, further comprising a chiller and wherein said water is chilled to a temperature between 1 degree C. and 5 degrees C.

17. The system as recited in claim **13**, wherein said sanitizing solution is collected but not re-used.

18. The system as recited in claim **13**, wherein said sanitizing solution contains a concentration of a biocide and wherein said control system is configured to measure concentrations of said biocide after contact with said produce.

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